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HEREDITY AND VARIATION; LOGICAL AND BIOLOGICAL.

By WILLIAM KEITH BROOKS.

(*Read April 20, 1906.*)

One need know little of the current literature of biology to be aware that many hypotheses have been proposed to account for the resemblance of offspring to parent. This resemblance is commonly held to be due to the transmission of a substance of inheritance, and we are told that this substance is the residence of the species and the bearer of its qualities.

Reproduction is the transmission of living matter of some sort, and it is part of the legitimate work of biology to discover, by the scientific method of observation and experiment, what it is in the transmission of which reproduction consists; but it by no means follows that there is meaning in our words when we call that which is thus transmitted in reproduction the substance of heredity, or the bearer of the species.

So far as the word is used inductively in biology, heredity is the resemblance of child to parent, of offspring to ancestor, while the difference between child and parent is called variation. These words are also used metaphorically to designate the cause or the explanation of the resemblances and differences between descendants and ancestors, just as gravitation is used metaphorically to designate that which makes things gravitate, geotropism that which makes roots grow downwards, and selection that which brings about survival in the struggle for existence. In what I have to say I shall restrict myself to the inductive meaning of the words, for I know that your thoughts are so free from the bonds of metaphysics that you know we accomplish nothing by saying that heredity makes beings inherit, or that variation makes them vary, or that selection selects.

Let us consider the word inheritance as a term to designate the resemblance between child and parent. You know that while the descendant does, on the average, resemble its ancestors and collateral

relatives more than it resembles anything else in nature, it is never identical with them. We say, in our careless way, that organisms exhibit specific identity behind or in spite of their individual diversity, when all we mean is that, while they resemble their parents, they are never identical with them. This diversity in unity is common to all natural objects, but it is most impressive in familiar living beings, in our friends and acquaintances, in our dogs and horses, and in the plants that we tend with our own hands. We may think of the casual stranger in the crowded street, or the unknown citizen of Timbuctoo, or the stalks in the cornfield that we pass in the train, as representatives of species and nothing more, but all the living beings we know practically we know as individual members of their kind.

If we are permitted to reason from the living beings we know best to those that concern us less, we must conclude that every living being is a unique member of its kind. It is more like its kind than like anything else in nature, but it is unique for there is nothing else in nature just like it. Reproduction is not the generation of like by like in any literal or mathematical sense. It is, rather, the generation of unique beings that are, on the average, more like their allies than they are like anything else in nature. We may for our own purposes, and in our minds, consider their kinship apart from their individuality, but this does not show that their kinship is separated from their individuality in fact. Living beings do not exhibit unity and diversity, but unity in diversity. These are not two facts but one. The delight of intimate acquaintance with animals is due to the inseparableness of their specific unity from their individuality, and our attempts to separate in our minds what is not separable in fact lead us to two narrow and imperfect views of the facts, two crude and unfinished mental concepts, neither of which corresponds to anything in nature.

All this is familiar, but I ask you to reflect upon it, to decide for yourselves whether it does not mean that inheritance or resemblance to ancestors, and variation or difference from ancestors, are only imperfect mental concepts; crude ideas, and not facts; whether the fact is not the individuality in kinship of living beings. Each of you must answer this simple question for himself. I cannot regard them

as facts, as they seem to me to be only imperfect ideas of facts, mental states which have arisen through a partial and uncritical view of our experience, to the neglect of that which has not interested us nor seemed to concern us.

If you agree with me that resemblance to ancestors does not exist in nature separated from individuality or difference from ancestors, that inheritance is not a fact but an imperfect idea of facts, admitting of improvement by comparison with nature, and in no other way,—if you agree to this, what becomes of the notion of a substance of inheritance? There is, no doubt, a material equivalent for every mental concept, and the material equivalent of heredity may be in the brain of the speculative philosopher, for I cannot find it in living beings nor in germ cells nor in chromatin.

I hope you will not accuse me of opposing the scientific study of inheritance and variation, for nothing is farther from my intention. The resemblances and differences between ancestors and descendants are as worthy of study as arithmetic, which has been of inestimable value to mankind although there is in nature no quantity without quality.

We cannot make progress in natural knowledge without specializing ; picking out what interests us and ignoring what does not seem to concern us ; but specialization is not an unmixed benefit, and if it blinds our eyes to the real world that lies before them it may prove to be an unmitigated evil ; leading the modern scientific man into the forlorn agnosticism of the ancient philosophers who held that we can never know anything because no real thing exists abstractly. Things do not cease to be because we fail to note them, and when we fix our attention upon some partial and imperfect conception of nature to the neglect of that which does not interest us, we may forget the reality of that which we have failed to consider, and we may thus be led to opinions which seem to be the logical conclusions of sound reasoning when they are but new illustrations of the threadbare fallacy of the undistributed middle—the fallacy which comes from mistaking a part for a whole.

The paradoxes into which the biologists fall in their efforts to locate the substance of inheritance remind me of the perplexity of the school boy, who, having tried to add together six horses and

nine cows and five apples, wonders whether the result is horses or cows or apples. If he were to attribute the virtue of his arithmetic to a substance of numeration and to wonder whether it resides in cows or apples, he would be still more like those who speculate about the location of the substance of inheritance, and think they have put their finger on it when they have called it idioplasm.

If you choose to declare that my contention, that inheritance is not a fact, is a metaphysical subtilty, I cannot help it. Call me a metaphysician if you will. But may it not be the speculative biologist who hunts in germ cells and in their chromatin for the physical basis of the crudity of his ideas who is the true metaphysician, and not I, who plead for nothing but the correction of our scientific concepts and their reduction to exactness by comparison with nature?

Science is making marvellous revelations of the order that pervades the apparent disorder of nature, showing us, by the method of analysis and comprehension, the most wonderful and admirable evidence of regularity in the course of events that had seemed to be chaotic, but this statistical method deals with averages while the natural world is concrete. No living being is a statistical average, and it is the peculiar task of biological science to recall our attention to the diversity of the statistical data, thus making equally marvellous and equally instructive revelations of the inexhaustible variety and boundless wealth of nature, for science deals with progress and discovery, not with finality, and the test of truth is nature and not logic.

Statistical science shows that there is, on the average, about one chance in some thousands that the average human being will commit murder or suicide within the year, but my friend is not a two hundred thousandth of a murderer, and I prize him because there is no one like him.

The biometrician tells us of a standard or norm, from which living beings recede by variation, and to which they approximate by heredity, but the normal or average living being does not exist in nature. The student of statistical science talks glibly of the normal man as if he were a public character, the familiar acquaintance of men of intellect, and a well known face to even the common herd. The biologist declares that he knows no such person;

that all men are particular men, concrete and unique ; that the normal man is a fictitious character, a statistical average, reached by ignoring all that is distinctive of each human being.

One can easily see why the notion that species is in germ cells has come to prevail. Nothing in nature, except the human mind, is easier to contemplate as an independent, self-sustaining, self-sufficient whole than is an egg. The symbolical comparison of the universe to an egg appeals to all, for nothing is easier than to think of an egg as a metaphysical thing in itself, a self-centred and self-sufficient microcosm. For many of the practical purposes of the scientific embryologist it is convenient and legitimate to regard it as a complete and self-sufficient being, but one must not forget what these practical purposes are, for the use of a concept for a practical purpose is apt to end in belief that it is true in general and useful for all purposes, and thus to entangle one in unforeseen paradoxes.

Every reflective biologist must know that no living being is self-sufficient, or would be what it is, or be at all, if it were not part of the natural world, although no truth is easier to lose sight of. Living things are real things, and we can never know too much about them, but their reality is in their interrelations with the rest of nature, and not in themselves.

Surely, this is good sense and good science. No physiologist who studies the waste and repair of living bodies ; no naturalist who knows living beings in their homes ; no experimental embryologist who studies the influence of conditions, internal and external, upon development, should, for an instant, admit that a living being is self-sustaining or self-sufficient, or that its being is in itself ; for the line we draw, for our own convenience, between living things and the external world, is not one that we find in nature, but one that we make for our own purposes.

The external world of a living being is as essential to it as its histological structure. If the environment of its body, or of any cell within its body had been different, neither cell nor body would be what it is, and if they had no environment they would not be at all, for neither seeds nor eggs nor desiccated rotifers exist ab-

strictly. A self-sufficient and self-sustaining living organism, whose being is in itself, is as fabulous as a griffin or a centaur, but no naturalist thinks, for an instant, that this truth casts any doubt upon the real existence of living things. While living things are real their reality or being is not absolute but dependent and relative.

One modern school of embryologists tells us that while the development of the egg into an individual organism is due to the reciprocal interaction between the germ and its environment, the species is in the germ as it is in itself; because, if it were not, like could not produce like. Like never does produce like, in any literal or absolute sense. If what has come about once may come about again under like conditions; it is among the possibilities of nature that a new animal kingdom, as rich and diversified as the one we know, might arise, in course of ages, from a starting point in the germ cells of some modern animal; for we know of nothing in the architecture of germ plasm that forbids.

If I venture at this late day to point out that ancestral development may be as epigenetic, from beginning to end, as individual development, and that the species for which we are seeking is not, and cannot be in the germ, I do so because the discovery is neither new nor original with me. It is so old that "up to date" zoologists tell us it is antiquated, abandoned, no longer worthy the attention of advanced thinkers.

According to this view, the species is not in chromatin, nor in germ cells, nor in differentiated cells, nor in gemmules, nor in idio-plasm, nor in biophores nor in allelomorphs, nor in living beings at any stage of their existence, nor in the conditions of existence, because it is in that reciprocal interaction between the living being and the natural world, of which it is a part, which has been called the struggle for existence. Neither the stability of species nor the mutability of species is in living beings, because it is through extermination in the struggle for existence that the type is kept true to its kind, and also through this struggle that it becomes slowly changed.

You will note that it is as great an error to locate species in the external world as it is to locate it in germ cells, or in chromatin. It

neither exists in the organism nor in the environment, because it is in the reciprocal interaction between the two. The biological types of which the biometricians tell us are neither external standards to which living beings approach and from which they recede by variation, nor are they standards fixed in living beings by heredity. Inheritance and variation are not two things, but two imperfect views of a single process, for the difference between them is neither in living beings nor in any external standard of extermination, but in the reciprocal interaction between each living being and its competitors and enemies and sources of food and the others conditions of life.

If the being of the individual organism is not in itself, but in the reciprocal interaction between it and its environment, and if the being of species is not in germ cells but in the reciprocal interaction between living beings and their environment, then the being of the canine species is of the same sort as the being of a dog, and that of everything else in nature.

Is it as a self-sufficient thing in itself, or as part of the universe, that the stone exhibits gravitation? "When Sir Isaac Newton made his speech about the child and the pebble: "Did he mean," asks Dr. Holmes, "to speak slightly of a pebble? A body which knows all the currents of force that traverse the globe; which holds fast by invisible threads to the ring of Saturn and the belt of Orion." "This is certain," says Locke, "things however absolute and entire they seem in themselves, are but retainers to other parts of nature, for that which they are most taken notice of by us. Their observable qualities, actions, and powers, are owing to something without them; and there is not so complete and perfect a part that we know of nature, which does not owe the being it has, and the excellencies of it, to its neighbours; and we must not confine our thoughts within the surface of any body, but look a great deal farther, to comprehend perfectly those qualities that are in it."

Since these things are true, is it not time to have done, once for all, with the metaphysical, pre-Darwinian notion of species, as something that resides in germ cells and is handed down by a substance of heredity?